PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 625938C	FOR FURTHER ACTION	See Form PCT/IPEA/416
International application No. PCT/AU2004/000982	International filing date *(day/month/year)* 22 July 2004	Priority date *(day/month/year)* 22 July 2003

International Patent Classification (IPC) or national classification and IPC

Int. Cl.[7] H02P 6/18, H02P 7/295, H02P 21/00

Applicant

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1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 8 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. [X] *(sent to the applicant and to the International Bureau)* a total of 15 sheets, as follows:
      - [ ] sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      - [ ] sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.

   b. [ ] *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or table related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

[X]	Box No. I	Basis of the report
[ ]	Box No. II	Priority
[ ]	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
[X]	Box No. IV	Lack of unity of invention
[X]	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
[ ]	Box No. VI	Certain documents cited
[ ]	Box No. VII	Certain defects in the international application
[X]	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of the report
22 February 2005	11 November 2005
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized Officer **BAYER MITROVIC** Telephone No. (02) 6283 2164

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/AU2004/000982

Box No. I Basis of the report

1. With regard to the language, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:

☐ international search (under Rules 12.3 and 23.1 (b))

☐ publication of the international application (under Rule 12.4)

☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the elements of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):

☐ the international application as originally filed/furnished

☒ the description:

pages **1-89** as originally filed/furnished
pages* received by this Authority on with the letter of
pages* received by this Authority on with the letter of

☒ the claims:

pages as originally filed/furnished
pages* as amended (together with any statement) under Article 19
pages* **90-104** received by this Authority on **21 October 2005** with the letter of **21 October 2005**
pages* received by this Authority on with the letter of

☒ the drawings:

pages **1/68-68/68** as originally filed/furnished
pages* received by this Authority on with the letter of
pages* received by this Authority on with the letter of

☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.

3. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages
☐ the claims, Nos.
☐ the drawings, sheets/figs
☐ the sequence listing (*specify*):
☐ any table(s) related to the sequence listing (*specify*):

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

☐ the description, pages
☐ the claims, Nos.
☐ the drawings, sheets/figs
☐ the sequence listing (*specify*):
☐ any table(s) related to the sequence listing (*specify*):

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
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Box No. IV Lack of unity of invention

1. ☐ In response to the invitation to restrict or pay additional fees the applicant has:

   ☐ restricted the claims.

   ☐ paid additional fees.

   ☐ paid additional fees under protest.

   ☐ neither restricted nor paid additional fees.

2. ☒ This Authority found that the requirement of unity of invention is not complied with and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is:

   ☐ complied with.

   ☒ not complied with for the following reasons:

   The claims do not relate to one invention only (or to a group of inventions so linked as to form a single general inventive concept). I have found claims having different special technical features as follows:

   (1) Claims 1-7 are directed to a system for driving a direct current motor. It is considered that 1st switch coupled to an inductive element, 2nd switch controlled so that a current circulating through the inductive element circulates through the second switch if the 1st switch disconnects the terminal, a capacitor in parallel to the motor, an inductive element, means for measuring the current and a means for controlling the operation of switches comprises a first special technical feature.

   (2) Claims 8 and 9-11, 38 and 39 when appended to claim 8 is directed to a system for driving a direct current motor. It is considered that an arrangement including plurality of switches, diodes and magnetic elements configured as a DC-DC converter, a capacitor in parallel to the motor, an inductive element, a means for measuring the current and a means for controlling the operation of said arrangement comprises a second special technical feature.

   (3) Claims 12-22 and 40 when appended to claims 12-15 are directed to a system for driving a direct current motor. It is considered that a diode or synchronous rectification switch, a magnetic transformer, a switch coupled to magnetic transformer, a capacitor in parallel to the motor, a means for measuring the current and a means for controlling the operation of said arrangement comprises a third special technical feature.

   (4) Claims 23-31 and 32-34 when appended to them are directed to an airflow apparatus. It is considered that a brushless DC motor, an electronic circuit for controlling its operation, a power supply and a means for reducing power comprises a fourth special technical feature.

   (5) Claims 35-37 are directed to a system for powering a microprocessor based system. It is considered that a capacitor, a means to charge said capacitor, a switch coupled to capacitor a means for sensing voltage and a means for keeping switch closed comprises a fifth special technical feature.

   (6) Claims 41-46 are directed to a switching based AC-to-DC converter. It is considered that a rectifier, a 1st capacitor, an inductive element, a 1st and 2nd switch, a 2nd capacitor, a means for sensing current through the inductive element, a means for sensing voltage across 1st capacitor, a means for sensing voltage across 2nd capacitor comprises a sixth special technical feature.

   The feature common to all of the claims is at most a generic power-electronics and/or DC motor control circuit having generic switches, capacitors and inductors connected into a control/driver/filter network of an unspecified topology and functionally incompletely characterised. However this common feature is generic in the art of power electronics converters and DC motor controllers. Consequently the common feature does not constitute "a special technical feature" since it makes no contribution over the prior art. Since there exists no other common feature which can be considered as a special technical feature, no technical relationship between the different inventions can be seen and, therefore, the application is directed to more than one invention.

4. Consequently, this report has been established in respect of the following parts of the international application:

   ☒ all parts.

   ☐ the parts relating to claims Nos.

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/AU2004/000982

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims 1-34, 38, 40, 46	YES
	Claims 35-37, 39, 41-45	NO
Inventive step (IS)	Claims 1-7	YES
	Claims 8-46	NO
Industrial applicability (IA)	Claims 1-46	YES
	Claims	NO

2. Citations and explanations (Rule 70.7)

NOVELTY AND INVENTIVE STEP

1. 1st invention – claims 1-7. Following documents from ISR are considered:

D1: JP 59-025589, D2: US 4673851, D3: US 4473781

Document D1 discloses a system for driving a commutatorless DC motor having a series inductive element - 53, first switching means – transistor 51, second switch element – diode 52, a capacitor - 54, a means for measuring current – resistor 21 and means for controlling operation of the first and second switch – blocks 10 and 12. When the 1st switch disconnects the inductive element 53, current circulates through the second switch - 52. However this motor does not operate under conditions of the controlled current, for the control variable is the motor voltage rather than the current.

Document D2 discloses a driving circuit for DC motor having a series inductive element 23, a one or more capacitors in parallel to the motor - 32, 22, etc., first switching means – FET 25, second switching means – freewheeling diode 31, a means for measuring the current- 30, 28, 26, and a means for controlling the operation of first and second switching means – PWM controller 12. When the 1st switch disconnects the motor stator circuit and the inductive element 23, current circulates through the second switch – diode 31. However this system does not control the motor current, and the current sensor is only used as a current limiter.

Document D3 discloses a driving circuit for brushless DC motor comprising a series inductive element – choke coil 15, first switching means – transistor 17, second switching means – diode 20, a capacitor in parallel – 14, a means for controlling first and second switch – block 25 and 23. When the 1st switch disconnects the motor stator circuit and the inductive element 15, current circulates through the second switch – diode 20. Document does not disclose the current measuring means but rather a sensor 21 for measuring the rotor angular position and the circuit does not control the motor current.

In light of these observations it is considered that the subject matter of claims 1-7 is new and meets the requirements of Article 33(2) PCT with regard to novelty. It is also considered that the subject matter of these claims is not obvious and meets the requirements of Article 33(3) PCT with regard to inventive step.

2. 2nd invention – claims 8-11, 38, 39. Following documents from ISR are considered:

D2 – same as for invention 1, see above, D4: US 6008999

D5: US 4472666, D6: EP 478808, D7: JP 10-271883, D8: JP 11-235087

[Continued on further sheet]

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

1. A number of claims are not clear because of their multiple dependencies to more than one independent claim, which already lack unity. See for example claims 9, 10, 11, 18-22, 32-34, 38, 39, 40. For the purpose of these report dependent claims are arranged so to only belong to a single invention as identified in ISR.

2. Claims 8-46 do not define the circuit topology (ports of elements, their connections and/or circuit nodes) in sufficient details, so that they have been broadly construed.

3. At least claims 1-7 are not fully supported by the description because they do not define the essential feature of the feature "current control". By reading the specification as whole including applicant replies to written opinions it is seems to be necessary to clearly distinguish between the two following control situations:

a) The "current control", in which the motor transfer function does not have a pole created by the inductance and resistance of the motor,

b) The mere variation of the motor current as a consequence of the "voltage control" of the motor, in which case the motor transfer function does have such a pole and the motor current is strictly not considered a controlled variable.

While this circumstance may be well-known in certain areas of electrical engineering, such as DC servo motor control, it is considered that it is not widely adopted and therefore a clear definition of the essential features of "current control" seems to be necessary.

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

Continuation of: V

Document D2 discloses as DC motor drive as discussed above (invention 1). It is additionally observed that whole circuit acts as a switch-mode DC-DC converter.

Document D4 discloses (Figs. 1, 3, 5 and 7) a buck converter having a series inductive element and a magnetic system (transformer), plurality of switches (diode, MOSFET), capacitor in parallel to the load, switching means for controlling the operation of the MOSFET (column 1, lines 28-32). Converter can be used to operate DC motor (column 1 lines 15-20). Means for measuring current and its use to control the switching means is not disclosed.

Document D5 discloses (Fig.1) a brushless DC motor drive having a DC-DC switching converter 13, comprising series inductive element 94, capacitor in parallel 95, and plurality of switches 92 and 93. It can be operated as a buck or, with some modifications, as a boost converter (column 9 lines 30-40). Means for measuring current is disclosed - resistor 56 and means for controlling the operation upon measured current – block 9.

Document D6 discloses speed controlled DC motor having switching DC power supply unit 10, series inductive element 12, smoothing capacitor in parallel 3, diode 6, switch (MOSFET or IGBT) 5, control means 1 using measured current and current monitoring device 7.

Document D7 discloses a drive for DC motor comprising DC-DC converter 5 having plurality of switches (transistor 5a, motor driving circuit6), diode, inductance, capacitor in parallel. The apparatus does not measure motor current, but measures output voltage of the DC-DC converter (which is proportional to the motor current) to drive feedback to the control circuit 9.

Document D8 discloses control circuit for three-phase brushless DC motor comprising plurality of switches Q1-Q6, diodes D1-D6, serial inductances 20-22, parallel capacitors 23-25, current measuring means 7, control circuit 10. Circuit acts as a half-bridge DC-DC converter (see machine translation from PAJ, paragraph [006])

In light of these observations and pursuant to the deficiencies outlined in box VIII, it is considered that claim 8 lacks novelty comparing to disclosure of D2, D5, D6, D7 and D8: It is also considered that claim 8 lacks an inventive step comparing to D4, because the generic sensorless control of motors using measured current is known in the art.

Furthermore, appended claims 9-11, 38 and 39 are either also not novel or relate to parameters or structures that are merely matters of design choice when the general technical knowledge about the state of the art is used and hence they cannot contribute to patentable invention.

3. 3rd invention – claims 12-22, 40. Following documents from ISR are considered: D1-D8, see above.

As none of these documents disclose all characterising features of claims, all claims 12-22 and 40 are novel. However, pursuant to the deficiencies outlined in box VIII, claims 12-22 and 40 are considered not to involve an inventive step. The difference between independent claim 12 and any of the cited documents is, at most, in the combined use of (1) a generic magnetic transformer and (2) flyback or ringing choke converter. The difference between independent claim 14 and any of the cited documents is, in addition, in the use of (3) a generic synchronous rectification switch. However all these three block-components are well known in the art of power electronics (see any standard university textbook in power electronics and motor control). The applicant has only stated that they are present (as a "black-boxes") in the circuit that drives motor, while the number of ports these "black-boxes", their electrical characteristics and their actual circuit connection were left undefined. The claimed systems are incompletely specified – i.e. they are specified in a semi-generic and technically abstract manner. It is considered that claims 12 and 14 represent the statement of the problem to be solved, rather than the statement of the solution.

Furthermore, appended claims 13, 15-22 and 40 relate to generic parameters or structures that are merely matters of design choice when the general technical knowledge about the state of the art is used and hence they cannot contribute to patentable invention.

4. 4th invention – claims 23-34. Following documents from ISR are considered:

D9: US 2002/021100, D10: EP 963034, D11: WO 2000/033453, D12: EP 1271759

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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

Continuation of: V

Document D9 discloses An apparatus for producing DC voltage from a brushless DC motor driving an airflow apparatus (fan). It comprises a rectifier which rectifies back-electromotive force from the motor winding, a motor and a motor control circuit which is powered from another DC power supply. Document does not disclose the use of rectified voltage to power the electronic control circuit of the motor.

Document D10 discloses a drive circuit for brushless DC motor used to drive a fan. It comprises a two separate power supplies, Vin and Vcc, whereby first power supply is used to drive the motor. Second power supply is used to process the signal resulting from brushless motor but it is not powered from the motor. However, only one supply could be used for both circuits. No means to reduce power once resulting voltage reaches suitable value is disclosed.

Document D11 discloses motion control system used to drive brushless DC motor. It comprises a power supply 12, 18 to power the motor 22, two DC-DC converters 29 and 22 separate from power supply of the motor, which use the voltage used to power the motor and an electronic circuit to control the operation of the motor 20. However, two DC-DC power supplies do not use voltage resulting from the motor.

Document D12 discloses a speed control circuit for a brushless DC motor driving a fan. It has two power supplies separate from each other – "+V" used to drive the motor and "Vcc" used to power the speed control circuit.

In light of these observations it is considered that all claims 23-34 are novel because none of the documents disclose all essential features of the invention. However, pursuant to the deficiencies outlined in box VIII, it is considered that claim 23 lacks an inventive step because the differences are technically generic and are well known in the art ("means for reducing power to said electronic circuit...") or the characterising features are not sufficiently clear and were only broadly construed. For these reasons (generic and/or broadly defined features) claim 23 represents more a statement of the problem than the statement of the solution.

Furthermore, appended claims 24-34 relate to parameters or structures that are merely matters of design choice when the general technical knowledge about the state of the art is used and hence they cannot contribute to patentable invention.

5. 5th invention – claims 35-37. Following documents from ISR are considered:

D13: JP 2000350462., D14: JP 2000350448, D15: JP 08051736, D16: JP 08126312, D17: JP 2000245150, D18: US 5973942

D19: WO 2000/026740, D20: WO 2001/071895, D21: US 6218818, D22: GB 2086156

Document D13 discloses a system for powering microcomputer from a DC voltage having a capacitor 8 (Fig.1), a switch coupled to capacitor (transistor 6) which can connect power to the microcomputer (connected at output 10a, b) from either the charge accumulated in the capacitor or from the inductor or from both, a means for sensing the voltage in the capacitor 9 causing the PMW control apparatus 12 to switch the transistor on and off and so to keep the capacitor at desired value. While the document does not explicitly disclose that the current in the capacitor is substantially smaller than operating current of the microcomputer, it appears that this circuit can operate under such conditions.

Document D14 disclose switching power supply which can be used to power microprocessor based apparatus from a DC voltage 5 (Fig.1). It comprises a capacitor 12, a switch 7 which control charging and discharging the capacitor, detector circuit 14 for detecting capacitor voltage and controller 15 which controls the switching of the transistor 7 based on the detected output.

While the document does not explicitly disclose that capacitor current is substantially smaller, there is no reason why it can't be so.

Document D15 discloses power supply back-up circuit for microcomputer from a battery, which has two capacitors (113 and 115), switching and control transistors 119, 120 and output voltage detector which acts on the base of the control transistor 120, which turns the transistor 119 on and off, and which ultimately connect the microcomputer to either the battery or to the capacitors.

Documents D16 and D17 disclose similar technical concept as previous. Especially D17 uses optical coupling between the diode D3 and the transistor Q2 to feed the detected output voltage back to the controller 11, which opens and closes switch Q1.

[Continued on further sheet]

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

Continuation of: V

Each of the remaining documents D18-D22 disclose variety of power supply configurations which can power a microprocessor based system from a DC voltage, having at least one capacitor, one switch (typically a transistor) and output voltage detector whose signal is fed back to the control unit controlling the switching of the transistor to connect the output to the DC supply or to the capacitor. See especially Fig 3 of D18 (features 20, 52, Q1, 56, 100), Fig.1A of D18 (features 12, 36, 30 and 18), Figs. 2 and 3 of D20, Fig.2 of D21 and Fig.1 of D22 (especially feature called "step-down circuit").

In light of these observations, it is considered that claims 35 and 36 lack novelty comparing to any of the documents D13-D22, because all essential features are disclosed.
Furthermore, appended claim 37 is either already disclosed in, or relate to parameters or structures that are merely matters of design choice when the general technical knowledge about the state of the art is used and hence they cannot contribute to patentable invention.
Alternatively, had the claims 35-37 been construed in somewhat narrower scope, they could have been formally regarded novel. Nevertheless they would still lack an inventive step because the essential features of claims are defined in a generic and technically abstract manner. No specific circuit is disclosed but only a common system level description. Claims 35-37 represent no more than the statement of the problem, rather than its solution.

6. 6th invention – claims 41-46. Following documents from ISR is considered:
D23: US 6259613, D24: US 6178104, D25: US 6175218, D26: US 6091233, D27: US 6043997

Document D23 discloses a power factor correction circuit comprising a AC-DC rectifier 12 (Fig.2) having first capacitorC1 in parallel, boost converter 10 consisting of inductive element L connected to a terminal of the rectifier and the capacitor, first switch MOSFET 12 coupled to the inductive element, second switch (diode) D1 connected to the node between the inductive element and first switch, second capacitor C2, means for sensing voltage across the second capacitor Vout', switching controller 20 connected to the first switch 20. Means for sensing current through the inductive element L and means for sensing voltage across first Capacitor C1 are shown ion Fig.1 – Op Amp/comparator 9 and voltage divider R3—R4, respectively.
Document D24 (by the same applicant as D23) discloses the circuit which is more or less same or similar to that of D23.
Document D25 (by the same inventor as D24) discloses similar circuit as in D23 and D24, except that there is no first capacitor.
Document D26 discloses a power factor correction boost converter comprising AC-DC rectifier – BR1 (Figs.2 and 3), first capacitor C0 , inductor L1, first switch- MOSFET M1, second switch – diode D1, second capacitor C1. Switching controller, sensor of the inductor current and sensor of output voltage (which is proportional to the voltage on the second capacitor) are disclosed in Fig.3.
Document D27 discloses three-phase boost AC-DC converter comprising (Fig.5) rectifier 540, a first capacitor connected in parallel 560, inductive element 565 connected to the terminal or rectifier and capacitor, first switch 580 coupled to the remote terminal of the inductor, second switch – diode 585 controlled so that the current circulating through inductive element circulates through the second switch when the first switch disconnects inductive element from capacitor and rectifier, second capacitor 470 connected to the terminal of second switch. Concept of power factor correction is disclosed in column 1 lines 24-44.
In light of these observations and pursuant to the deficiencies outlined in box VIII it is concluded that claim 41 is not novel comparing to D23 and D24. Additionally claim 41 lacks an inventive step when compared to D25-D27, because the differences are either well-known in the art (eg. first capacitor in parallel) or they are defined in a generic, technically abstract terms (eg. means for sensing voltage...).
Furthermore, appended claims 42-46 are either also not novel or they relate to parameters or structures that are merely matters of design choice when the general technical knowledge about the state of the art is used and hence they cannot contribute to patentable invention.

The claims defining the invention are as follows:

1. A system for driving a direct-current (DC) motor under conditions of controlled DC current, from a DC voltage source of a value larger than said motor operating voltage, independently of the operating voltage of said motor, said system comprising:

a pair of nodes for connection of said DC motor, said nodes to be referred herein as the first node and the second node; said second node connected to a common electrical terminal of the system through an electrical path with low impedance, including low impedance to DC current; said DC motor is connected between said first node and said second node.

an inductive element to store energy and to act as a current source for said DC motor, said inductive element is external to said DC motor, and not part of said DC motor main magnetic circuit, said inductive element is connected to said first node, in series with said DC motor, said inductive element been capable of operating in a buck converter at the power level required to operate said DC motor and at the frequency of commutation of a first switch, the terminal of said inductive element not connected to said first node to be connected to a third node;

said first switch is connected to said inductive element at the third node, the terminal of said inductive element remote from said DC motor; said first switch used for connecting and disconnecting said inductive element to a direct current (DC) voltage source; a terminal of said DC voltage source not connected to said first switch, to be connected to said common electrical terminal of the system; said first switch is a controlled switch capable of being turned off and on (switch open or closed) by control signals from a control system; said control system operates based on an error signal and a value of the desired operating current for said DC motor set externally to the system; the object of said control system is to turn said first switch off and on (switch open or closed) in order to minimise said error signal and to keep the

operating current of said DC motor at said desired value; said first switch is a single pole switch;

a second switch connected between said third node and said common electrical terminal of the system, parallel with a combination of said inductive element and said DC motor arranged in series; said second switch controlled so that a current circulating through said inductive element circulates through said second switch if said first switch is turned off (switch open) and disconnects said inductive element from said DC voltage source; said second switch is a single pole switch;

a capacitor arranged for connection in parallel with said DC motor to limit a resulting voltage over said DC motor, said capacitor being capable of operating in a buck converter at the power level required to operate said DC motor and at the frequency of commutation of said first switch, said capacitor is connected between said first node and a low impedance path to said common electrical terminal of the circuit;

a current sensor for measuring a current through said DC motor; the output of said current sensor connected to said control system of said first switch to generate said error signal for the operation of said control system controlling the operation of said first switch,

means for controlling operation of said second switch dependent upon the state of the first switch.

2. The system according to claim 1, wherein the voltage of said DC voltage source is larger than the nominal rated voltage of said DC motor.

3. A system for driving a direct-current (DC) motor under conditions of controlled DC current, independently of the operating voltage of said motor, said system comprising:

a pair of nodes for connection of said DC motor, said nodes to be referred herein as the first node and the second node; said second node connected to a common electrical terminal of the system through an electrical path with low impedance, including low impedance to DC current; said DC motor is connected between said first node and said second node.

a capacitor arranged for connection in parallel with said motor to limit a resulting voltage over said motor, one terminal of said capacitor connected to said first node the other terminal of said capacitor to be connected through a low impedance to said common terminal of the system, said capacitor being capable of operating in a buck converter at the power level required to operate said DC motor and at the frequency of commutation of a first switch;

an inductive element with one terminal connected to said common terminal of the system through a low impedance path, the other terminal of said inductive element, referred herein as the third node, is connected to said first switch; said inductive element is used to store energy and to act as a current source for said DC motor, said inductive element been external to said DC motor, and not part of the said DC motor main magnetic circuit, said inductive element been capable of operating in a buck converter at the power level required to operate said DC motor and at the frequency of commutation of said first switch;

said first switch is connected to said inductive element in the third node, said first switch used for connecting and disconnecting said third node to a DC voltage source; a terminal of said DC voltage source not connected to said first switch, to be connected to said common electrical terminal of the system; said first switch been a controlled switch capable of been turned off and on (switch open and closed) by control signals from a control system; said control system operates based on an error signal and a value of a desired operating current for said DC motor, set externally to the system; the object of said control system is to turn said first switch off and on (switch open and closed) in order to minimise said error signal and to keep the operating current

of said DC motor at said desired value; said first switch is a single pole switch;

a second switch connected between said first node and said third node, that is, in series with the parallel combination of said motor and said capacitor, and connected to the common node between the first switch and said inductive element; said second switch controlled so that a current circulating through said inductive element circulates through said second switch if the first switch is turned off (switch opened) and disconnects the third node from said DC voltage source; said second switch is a single pole switch;

a current sensor for measuring a current through said DC motor; the output of said current sensor connected to said control system of said first switch to generate said error signal for the operation of said control system, controlling the operation of said first switch, and

means for controlling operation of said second switch dependent upon the state of the first switch.

4. A system for driving a direct-current (DC) motor under conditions of controlled DC current, independently of the operating voltage of said motor, said system comprising:

a pair of nodes for connection of said DC motor, said nodes to be referred herein as the first node and the second node, said DC motor is connected between said first and said second node.

a capacitor arranged for connection in parallel with said motor, between said first node and said second node, to limit a resulting voltage over said motor, said first node, connected to a terminal of said capacitor and said motor, being also connected to a DC voltage source, said capacitor being capable of operating in a buck converter at the power level required to operate said DC motor and at the frequency of commutation of a first switch; the other

terminal of said DC voltage source to be connected to a common electrical terminal of the system;

an inductive element with one terminal connected to said first node, a common node of said DC voltage source, said capacitor and said DC motor, the other terminal of said inductive element, referred herein as the third node and is connected to said first switch; said inductive element used to store energy and to act as a current source for said DC motor, said inductive element been external to said DC motor, and not part of the said DC motor main magnetic circuit, said inductive element being capable of operating in a buck converter at the power level required to operate said DC motor and at the frequency of commutation of said first switch;

said first switch is connected to said inductive element in the third node, the other terminal of said first switch, not connected to the third node is connected to said common electrical terminal of the system through an electrical path with low impedance, including low impedance to DC current; said first switch used for connecting and disconnecting the third node to said common electrical terminal of the system; said first switch been a controlled switch capable of been turned off and on (switch open and closed) by control signals from a control system; said control system operates based on an error signal and a value of a desired operating current for said DC motor set externally to the system; the object of said control system is to turn said first switch off and on (switch open and closed) in order to minimise said error signal and to keep the operating current of said DC motor at said desired value; said first switch is a single pole switch;

a second switch connected between said second and said third node, said second switch controlled so that a current circulating through said inductive element circulates through said second switch if the first switch is turned off (switch opens) and disconnects the third node from said common electrical terminal of the system; said second switch is a single pole switch;

a current sensor for measuring a current through said DC motor; the output of said current sensor connected to said control system of said first switch to generate said error signal for the operation of said control system, controlling the operation of said first switch; and

means for controlling operation of said second switch dependent upon the state of the first switch.

5. The system according to claim 1, 2, 3 or 4, wherein said second switch is a diode connected with appropriate polarity so that current circulating through said inductive element circulates through said diode if said first switch is open, disconnecting said inductive element.

6. The system according to claim 1, 2, 3 or 4, wherein said second switch is an electronic switch for synchronous rectification connected with appropriate polarity so that current circulating through said inductive element circulates through said electronic switch if said first switch is open, disconnecting said inductive element.

7. The system according to any one of claims 1 to 6, wherein said first switch is an electronic switch.

8. A system for driving a direct-current (DC) motor under conditions of a controlled average current, a voltage of a DC power supply having a larger or smaller value than a motor nominal voltage, said system comprising:

an inductive element for connection in series with the DC motor, said inductive element capable of operating in a buck converter at the power level required to operate said DC motor and at the frequency of a first switch;

an arrangement including a plurality of switches, diodes and a magnetic system, said arrangement coupled to said inductive element for

connecting and disconnecting a terminal of said inductive element remote from said motor to a voltage source, said arrangement configured as circuit selected from the group consisting of:

- a forward DC-DC converter
- a push-pull DC-DC converter
- a half-bridge DC-DC converter
- a diagonal-half bridge DC-DC converter
- a full bridge DC-DC converter

a capacitor arranged for connection in parallel with said motor to limit a resulting voltage over the motor, said capacitor capable of operating in a buck converter at the power level required to operate said DC motor and at the frequency of commutation of said first switch;

means for measuring a current through the motor; and

means for controlling operation of said arrangement dependent upon said measured current in the motor.

9. The system according to any one of claims 1 to 8, wherein said inductive element is an inductor, or a winding of a transformer.

10. The system according to any one of claims 1 to 9, wherein a current through the inductive element can be controlled independently from a current through the motor, the balance of electrical charge being accumulated or taken from the capacitor in parallel with the motor.

11. The system according to any one of claims 1-10, wherein a current through the inductive element is modulated as a full wave rectified sinusoid synchronous with the AC main voltage so that the power factor of the system, as a load to the AC main is improved.

12. A system for driving a direct-current (DC) motor under conditions of a controlled average current, a voltage of a DC power supply having a larger or smaller value than a motor nominal voltage, said system comprising:

a diode;

a magnetic transformer connected in series with said diode in a circuit arrangement selected from the group consisting of a flyback DC-DC converter and a ringing choke DC-DC converter, said transformer and said diode for connection in series with the DC motor;

a switch coupled to said magnetic transformer and said diode for connecting and disconnecting a terminal of said magnetic transformer and said diode remote from said motor to a voltage source;

a capacitor arranged for connection in parallel with said motor to limit a resulting voltage over the motor, said capacitor capable of operating in a buck converter at the power level required to operate said DC motor and at frequency of commutation of said switch;

means for measuring a current through the motor; and

means for controlling operation of said switch dependent upon said measured current in the motor.

13. The system according to claim 12, wherein said switch is an electronic switch.

14. A system for driving a direct-current (DC) motor under conditions of a controlled average current, a voltage of a DC power supply having a larger or smaller value than a motor nominal voltage, said system comprising:

an electronic synchronous rectification switch;

a magnetic transformer connected in series with said synchronous rectification switch in a circuit arrangement selected from the group consisting of a flyback DC-DC converter and a ringing choke DC-DC converter, said transformer and said synchronous rectification switch for connection in series with the DC motor;

a switch coupled to said magnetic transformer and said synchronous rectification switch for connecting and disconnecting a terminal of said magnetic transformer and said synchronous rectification switch remote from said motor to a voltage source;

a capacitor arranged for connection in parallel with said motor to limit a resulting voltage over the motor;

means for measuring a current through the motor; and

means for controlling operation of said switch dependent upon said measured current in the motor.

15. The system according to claim 14, wherein said switch is an electronic switch.

16. The system according to any one of claims 12-15, wherein a current through the flyback inductance can be controlled independently from a current through the motor, the balance of electrical charge being accumulated or taken from the capacitor in parallel with the motor.

17. The system according to any one of claims 12-16, wherein a current through the flyback inductance is modulated as a full wave rectified sinusoid synchronous with the AC main voltage so that the power factor of the system, as a load to the AC main is improved.

18. The system according to any one of claims 1 to 17, further comprising a DC motor.

19. The system according to claim 18, wherein said DC motor includes a brush-less DC motor.

20. The system according to claim 19, wherein said DC motor includes an electronic commutator for said brush-less DC motor.

21. The system according to any one of claims 1-20, wherein said means for measuring said current through the motor includes means for calculating said current though the motor dependent upon current measured in another part of said system.

22. The system according to any one of claims 1-21, wherein a frequency of a pulse width modulated waveform, resulting from operation of said switches, is randomised to facilitate EMI compliance.

23. An airflow apparatus, comprising:

a brush-less DC motor;

an electronic circuit for controlling operation of said brush-less DC motor;

a power supply for said electronic circuit separate from a power supply for said brush-less DC motor, said power supply for said electronic circuit adapted to use a voltage resulting from said brush-less DC motor in operation once said resulting voltage reaches a suitable value; and

means for reducing power to said electronic circuit from said power supply once said resulting voltages reaches said suitable value.

24. The airflow apparatus according to claim 23, wherein said apparatus is an airflow generator.

25. The airflow apparatus according to claim 24, wherein said airflow generator is for use in medical applications.

26. The airflow apparatus according to any one of claims 23-25, wherein said reducing means comprises means for disconnecting said electronic circuit from said power supply for said control electronics.

27. The airflow apparatus according to any one of claims 23-26, wherein said electronic circuit comprises an electronic commutator or driving electronics for said brush-less DC motor.

28. The airflow apparatus according to any one of claims 23-27, wherein said electronic circuit comprises a buck converter or down converter switched mode power supply connected to a rectified AC main voltage.

29. The airflow apparatus according to any one of claims 23-28, wherein said electronic circuit comprises means for controlling current through said brush-less DC motor.

30. The airflow apparatus according to any one of claims 23-29, wherein said electronic circuit utilizes a pulse width modulated square wave applied through a transformer to control a voltage over said motor.

31. The airflow apparatus according to claim 30, wherein said transformer is part of a forward converter, a push-pull converter, a half bridge converter, a diagonal half bridge converter, a bridge converter, or a flyback converter.

32. The airflow apparatus according to claim 23, further comprising a driving system according to any one of claims 1-11, wherein said electronic circuit controls a current through said brush-less DC motor (BLDCM), where said inductive element is a winding of a transformer having a plurality of secondary windings, a secondary winding being used to provide power to said electronic circuit.

33. The airflow apparatus according to any one of claims 23, 26, 27, 28, 29, 30, 31, and 32 wherein said airflow generator is for use as a cooling fan or a ventilation fan.

34. The air flow apparatus according to claim 33 wherein a plurality of brushless DC motor driven ventilation fans or cooling fans are connected in series between each other.

35. A system for intermittently powering a microprocessor based system from a DC voltage higher than the voltage required by the system to operate, comprising:

a capacitor;

means to charge said capacitor from the DC voltage with a current substantially smaller than the current the microprocessor based system needs to operate;

a switch coupled to said capacitor so that said switch can connect power to the microprocessor based system from the charge accumulated in the capacitor;

means for sensing the voltage in the capacitor and causing the switch to close once the voltage in said capacitor reaches a desired value; and

means for keeping the switch closed while the voltage in said capacitor is over a desired value, but less than the value that caused said sensing means to close the switch.

36. The system according to claims 35, wherein said switch is an electronic switch.

37. The system according to claims 35 or 36, further comprising means for limiting current through said switch.

38. The system according to claims 10 or 16 wherein the current through the motor is calculated from the variation of the voltage across the capacitor in parallel with the motor.

39. The system according to claim 11 or 17, wherein the instant in which the sinusoidal waveform of the AC main crosses zero is sensed to synchronise the modulation performed to the current through the inductive element with the waveform in the AC main.

40. The system according to any one of claims 1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14 and 15, wherein the voltage over the DC motor is used to estimate the speed of the motor.

41. A switching based alternating current (AC) to direct current (DC) converter, comprising:

a rectifier adapted to be connected to an alternating current (AC) mains line, said rectifier having at least one output comprising two nodes, to be referred herein as the **output common node** and the **input common node**;

a first capacitor for noise reduction connected between said **output common node** and said **input common node**;

an inductive element connected to said **output common node**;

a first switch connected between said **input common node** and the terminal of said inductive element not connected to said **output common node**; said first switch used for connecting and disconnecting a terminal of said inductive element remote from said **output common node**, the connection node between said inductive element and said first switch to be referred herein as the **first node**;

a second switch connected to said **first node**, controlled so that the current circulating through said inductive element circulates through said second switch when said first switch disconnects said inductive element from said **input common node**, the node of the second switch not connected to said **first node** to be referred herein as the **DC output node**,

a second capacitor for energy storage connected between said **DC output node** and said **output common node**,

means for sensing a current through said inductive element;

means for sensing the voltage across said first capacitor;

means for sensing the voltage across said second capacitor, the voltage across said second capacitor to be referred herein as the **output voltage**;

a control circuit using the sensed value of the voltage across said first capacitor, and the sensed value of the **output voltage**, said control circuit connected to said first switch to maintain said **output voltage** between defined limits by operating said first switch in a way that said current through said inductive element tracks the waveform of the alternating current line voltage, to cause said switching based AC to DC converter to exhibit unity power factor to the alternating current line.

42. The converter defined in claim 41, wherein said second switch is a diode.

43. The converter defined in claims 41 or 42, wherein said first switch comprises a field effect transistor.

44. The converter defined in claim 41, 42, or 43, wherein said rectifier comprises a full-wave diode rectifier.

45. The converter defined in claim 41, 42, 43 or 44, wherein said inductive element is an inductor, or a winding of a transformer.

46. The converter defined in claim 41, 42, 43 or 45, wherein a frequency of a pulse width modulated waveform controlling said first switch or said second switch, resulting from operation of said switches, is randomised to facilitate EMI compliance.